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The Fermi Function, Factorization and the Neutron's Lifetime

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The neutron lifetime is a precision observable of the Standard Model probing the CKM matrix element $|V_{ud}|$ and beyond the Standard Model physics. For nuclear beta decay, in the region of small electron velocity or the limit of large nuclear charge Z, a Fermi function is used to account for enhanced perturbative effects. In this talk, I will present the derivation of the quantum field theoretic analog of the Fermi function valid for neutron beta decay in which neither of the aforementioned limits apply. This QFT analog is related to renormalization group effects of objects occurring in the context of a factorization formula valid in the limit of small electron mass. I will introduce this factorization formula and present results through two-loop order. The main phenomenological results are two-loop input to the long-distance corrections to neutron beta decay and an accompanying calculation of $|V_{ud}|$.

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